The New LS7

The most significant Corvette engine since the first small-block?

Once again, the big news from General Motors revolves around the Corvette, this time centering on the introduction of the race-derived427-cube LS7 powerplant that motivates the new '06 Z06. With a rated 500hp at 6,200 rpm and a 7,000 rpm redline, it's an engine that's sure to please.

From an engine builder's perspective, looking at new OE engine designs almost always leaves us with a trace of self satisfaction and maybe a hint of smugness. Looking over a newly introduced factory powerplant, we may say, "That's a nice piece." Inside, however, the hot-rodder that lives in our consciousness leaves us with a pleasant thought: Nice for a stocker, but I can make it better.

Qualified that way, we feel an air of haughtiness, real or imagined, while reveling in what the OE left on the table for us to exploit. Some porting in the heads, a little more compression, trick rings and bore finishes, lightweight parts, and soon; our hot-rodder's bag of tricks runs deep. Unconstrained by the impositions faced by mass production, our custom efforts allow us the fancy of outdoing monolithic corporations wielding unimaginable resources. Normally, this ego self-gratification is part and parcel of any OE engine review. Then it happened: the LS7 small-block debut. The only reactions for someone truly in the know are deference and awe.

The fantastic cylinder heads define the engine and are key to its power production. Reportedly achieving airflow in the realm of serious race pieces, the ports are substantially revised.

The size alone gives it credence: 427 cubic inches in its all-aluminum splendor. Matching the displacement (coincidentally?) made famous by the most legendary of performance Corvettes from a generation long past, this is the largest "small-block" engine ever produced by GeneralMotors, while maintaining the external dimensions of previous Gen IV small-blocks. But it encompasses so much more than its internal girth.With a rated output of 500 SAE net horsepower at 6,200 rpm, the real mechanical energy emanating from this beast far outstrips any of the big-blocks of yore.

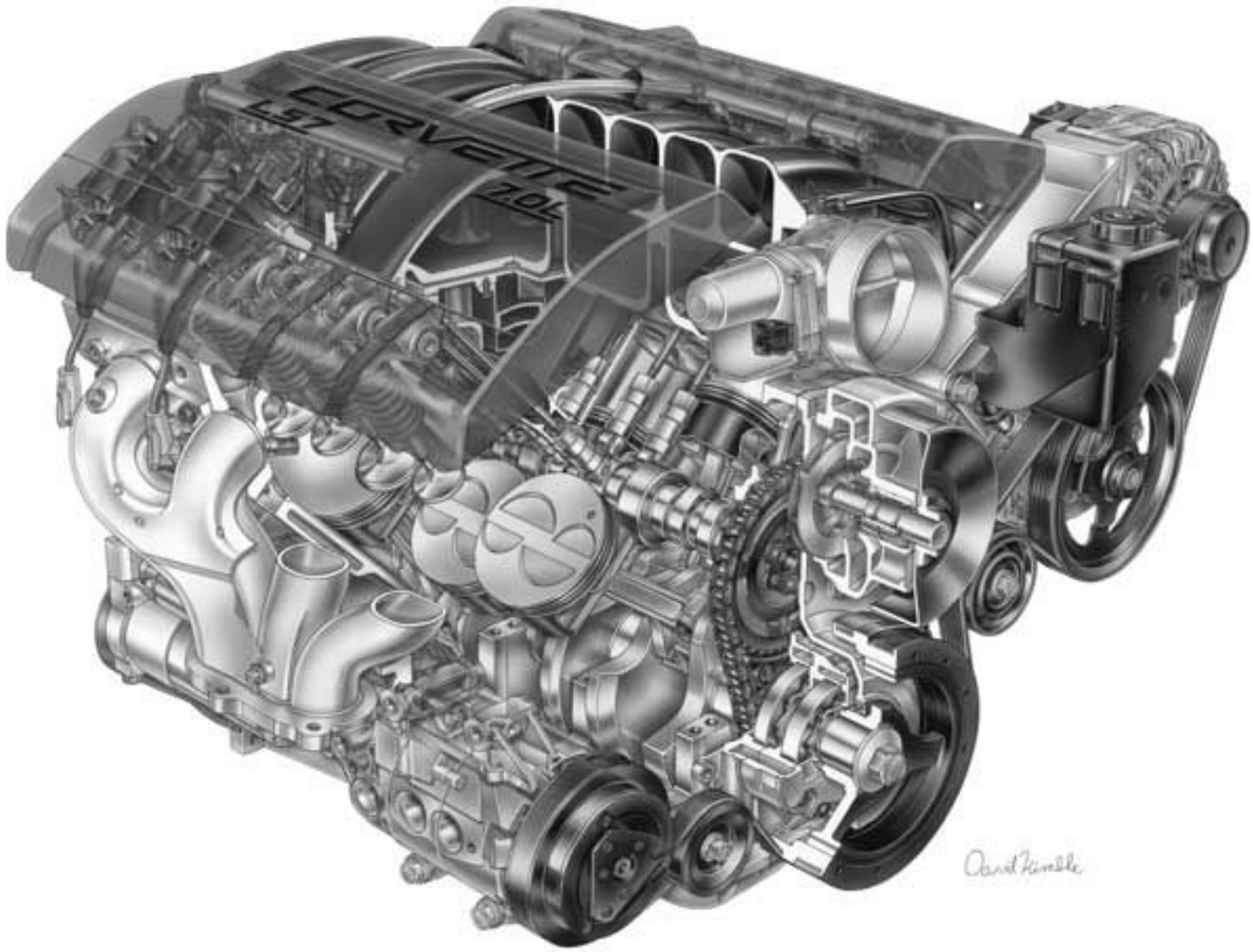
Based on the groundbreaking Gen IV small-block architecture introduced as the LS1 in 1997, the LS7 is much more than simply a displacement increase. It's an exotic 7,000-rpm race-derived powerplant brought upon the public at a level of execution unrivaled in any production car. Dave Muscaro, assistant chief engineer for passenger car V-8s, put it succinctly, "In many ways, the LS7 is a racing engine in a street car. We've taken much of what we've learned over the years from the 7-liter C5-R racing program and instilled it here. The reality is, there has been nothing like it offered in a GM production vehicle."

Why Size?

The intake ports are said to flow in the 360-cfm range at 28-inch water depression, and are fully CNC-ported. Ports feature a revised raised entrance and a larger cross section to work with the larger displacement of the LS7.

It seems intuitive that larger displacement offers a greater potential for power. Detroit manifested this theorem in the big-block engines of the '60s. A keener appreciation for the need to increase displacement comes with a more intimate knowledge of the relationships between torque and horsepower, torque potential, and rpm. We'll illustrate the point as we spell out a simple proof. Normally aspirated engines have a finite torque potential based on volumetric efficiency and displacement.Horsepower is derived as a computation based on torque and rpm.

Think about these two physical realities: Torque is limited by cubic inches and efficiency. Horsepower is derived from torque and rpm.



If the goal is more horsepower, and torque production is at the limits of the size and efficiency available, there are only two avenues left to achieve more power: increase size or raise rpm. In the progression of the GM small-blocks, the torque potential of the original LS1's displacement was significantly exploited, particularly in the LS6 configuration of the previous Z06 powerplant. Increasing output by a significant measure, such as the 25 percent gain achieved with the LS7, could only have been accomplished by employing much higher rpm, or the larger engine. The larger engine was the obvious choice. The larger displacement delivers glorious torque in greater abundance from lower in the rpm range than can possibly be achieved with a smaller engine in normally aspirated form. Maintain that torque as far up the power curve as practical, and you've found horsepower nirvana. That's what was accomplished with theLS7 engine.

While it may seem like a simple requirement, maintaining torque into the high-rpm ranges becomes increasingly difficult as the displacement of the engine is expanded. Torque peaks when airflow and velocity through the intake ports and the limits of cam timing are reached. In the racing aftermarket, this point in the power potential of an engine is referred to as "port saturation." Apply the same cylinder head to a larger-displacement engine, and the torque produced will be higher as a function of displacement, but the limitations of port flow and velocity curb torque production earlier in the rpm range, which hinders peak power output.

To achieve their goals of abundant power output into the upper rpm range with the larger-displacement engines, the LS7 required a spectacular cylinder head, and a close examination of its layout makes it clear this requirement wasn't lost on the GM development team.

Cylinder Head And Valvetrain

Combustion chambers are likewise fully machined to this masterfully sculpted form and are stuffed with enormous 2.200-inch intake valves and1.61-inch exhaust valves. The valve angle in the cylinder heads relative to the decks has been altered to 12 degrees for enhanced airflow, a departure from the 15-degree angle employed by other Gen IV small-blocks. The chamber design offers significant quench area for efficient combustion.

We examined the LS7 cylinder head at the GMTech Center in Southern California, and were stunned by the execution.On paper, the specifications alone were impressive: 2.200-inch intake valves, 1.61-inch exhaust valves, and CNC-porting of the intake and exhaust runners and chambers. These are healthy valve sizes, and theCNC-porting is a unique attribute. However, the port configuration and shape made an impression. A cylinder-head port is more than a hole in a chunk of aluminum. Coaxing air through a passage at high rates is an art hard to appreciate without having lived with the flow bench and die-grinder, carving shapes, testing, chasing the elusive motion of invisible gasses. It's a specialized world unto its own, mastered by few, where the subtle hips of the port throat are as sexy as those of a pop princess. Those passages become personal and identifiable, and as individual as a signature. Those ports are the work of a master craftsman with a grasp of the nuances of airflow and port shape that made it clear these cylinder heads are truly something special. Sure enough, we found out the cylinder-head design was a collaborative effort between General Motors Engineering and renowned aftermarket airflow expert Mike Chapman.

The intake ports are substantially enlarged, providing the critical cross-sectional area required for maintaining torque production high into the rpm range. Allowing the greater cross-section are offset intake rocker arms, spreading the pushrods away from the port centerline and eliminating the restraint to the port width they impose. To gain a more advantageous geometry for airflow into the cylinder, the intake ports are significantly raised in comparison toLS1/LS6/LS2 configurations. The intake-valve inclination angle was reduced to 12 degrees from the previous engines' 15-degree angle. The higher port approach and shallower valve angle are modifications straight from the realm of serious small-block race-engine building.

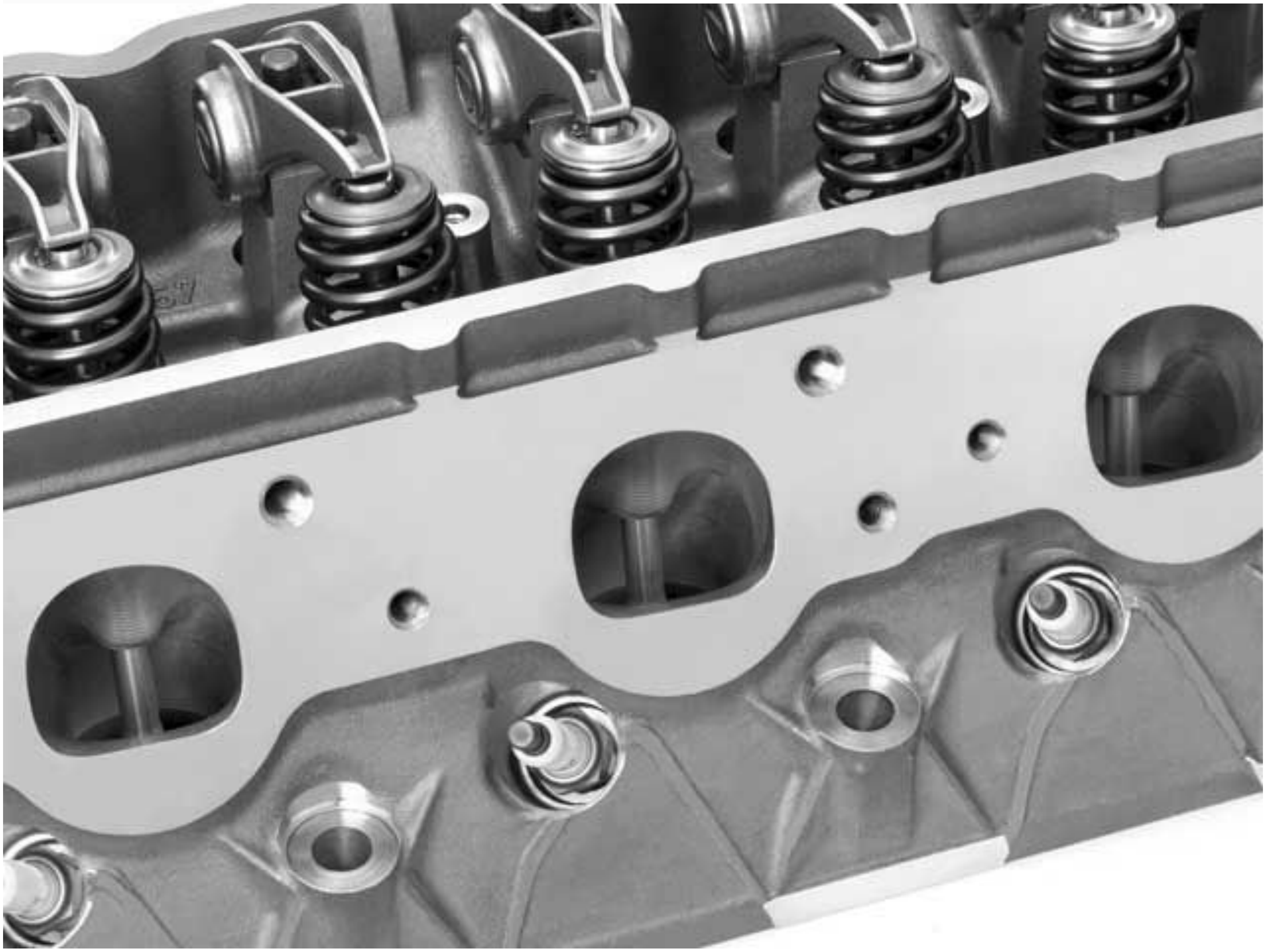
The intake and exhaust valves are longer than the previous Gen IV valves, providing room for deeper ports in the bowl area and over the port's critical short-side turn. The intake valve is titanium, while the exhaust features a hollow sodium-filled stem for enhanced heat transfer.

The valves are longer overall in stem length than those used in other engines from this family. Longer valves ease the constraints to port height, valve spring height, and valve lift, which can be applied to producing a performance-minded cylinder head. The valve lift is increased to .591 inch, a level unheard of in a production engine.Helping achieve that level of lift is an increase in rocker-arm ratio to1.8:1, in contrast to the 1.7:1 seen in other small-blocks. The advantageous use of the rocker ratio results in a fast action at the valve, allowing the valvetrain to take advantage of the cylinder heads' abundant high-lift flow, without the requirements of extreme camshaft duration. This would be impractical from the standpoints of emissions, efficiency, and smoothness. The radical valve-opening rates can present a control limitation at high rpm. The use of titanium valves on the intake and a lightweight, hollow-stem, sodium-filled exhaust valve lighten the reciprocating weight at the valve. A longer, highly refined valve spring with small titanium retainers offer control. Again, these techniques are derived from the race-engine building world.

This paring of an intake and exhaust rocker illustrates the 9mm offset employed on the intake rocker (left). The offset alters the pushrod position outward, providing increased port width in an area normally constricted. The lightweight rockers are highly refined for low mass and inertia, and feature needle-bearing pivots. The rocker ratio has been increased to 1.8:1, amplifying the motions directed by the camshaft.

Flow is given in engineering parlance of 203 grams per second at the intake and146 grams per second at the exhaust, measured at the peak valve lift of.591 inch. We were officially told the cylinder heads flow 43 percent better than the LS6 on the intake and 26 percent better on the exhaust.Leaning on GM sources for numbers without the strain of volume/mass metric/imperial conversions, we heard flow figures of 360 cfm on the intake and 214 on the exhaust at .591-inch lift, at the performance industry's standard measuring spec of 28-inch water depression. Flow numbers like these are so far beyond the realm of production engines it's astounding. Put into perspective, a good aftermarket head for an old-style small-block flows 250 cfm. A good sportsman race head breaks 300 cfm, while these numbers were seen on full-house NASCAR-style heads.

Total Flow



The deep CNC-ported exhaust ports are said to deliver 214 cfm of airflow at 28-inch water depression. Also visible are the beehive-shaped valves springs, which reduce critical mass and are less prone to harmonic disturbance than conventional parallel-wound springs. The small-diameter retainers also reduce mass at the valve side of the system.

Although great things were achieved with the cylinder head, it is one link in the chain of flow into and out of the engine. The flow system begins with the Donaldson PowerCore airbox where attention is given to flow efficiency and flow is increased 20 percent as compared to the LS2. To work with the revised cylinder-head intake-port configuration, an all-new intake manifold was developed to meet the high airflow demands. Like the other Gen IV small-block intake, this intake is of friction-welded, three-piece construction, produced from a composite material. The throttle body was enlarged to 90 mm, and the injectors were uprated to meet the demands of the engine's requirements.The exhaust system features hydroformed individual tube headers leading to a unique inline collector flange. A sweeping collector forms a tapered transition from the header flange into the wide-mouth high-flow catalysts mounted immediately aft.

The exhaust system features hydroformed individual tube headers leading to a unique in-line connector flange. A sweeping collector forms tapered transition from the header flange into the wide-mouth high-flow catalysts mounted immediately aft. The exhaust system features a pipe diameter of3 inches.

The Pump

Titanium is used as the connecting-rod material, an exotic find even in racing engines. Strength, light weight, and fatigue resistance make it a worthy upgrade in a large, high-rpm engine like the LS7.

The bottom end of the engine comprises the short-block assembly, and the exotica found at the top of the LS7 is continued downstairs. The job was to accommodate the displacement increase, and build in a level of strength and reliability suitable for high-rpm operation. The LS7 block is unique, partially to meet the increase in displacement and partially to withstand the output the engine is designed to produce.

The engine block features a bore size of4.125 inches and, rather than the cast-in-place liners of the other GenIVs, receives thicker-walled pressed-in dry cylinder liners. The bores are finished with torque plates fastened to the decks to simulate the distortion created by the cylinder-head fasteners. The main caps are installed and torqued during machining operations. This procedure, typical of custom-built racing engines, allows machining and finish sizing to be accomplished while the block is stressed analogous to after final engine assembly. Truer tolerances in the assembled engine are the result.

Adding to the strength of the bottom end is the use of six-bolt doweled forged-steel main caps in the place of the powdered-metal material used on other Gen IVs. The main caps secure a 4.00-inch stroke crankshaft forged from 4140 chrome-moly steel, with rolled fillets where the journals meet the cheeks. This specification of crankshaft is more akin to a race crankshaft than the undercut-fillet carbon-steel forgings used in older production engines. While the high-grade steel in the crank is notable, the real news in materials relates to the connecting rods. The use of titanium provides a uniquely high ratio of strength and fatigue life to weight. Titanium is exotic even in the racing world, and its use here is a first for a domestic auto manufacturer.

Other aspects of the LS7 engine borrow from principles having more in common with the racetrack than production automobiles. The lubrication system of the LS7is unique, as it's a variation of the dry-sump arrangement normally seen only on the racetrack. Rather than supplying oil from the bottom-mounted sump directly into the engine's pressure-fed lubrication system, the LS7employs a two-stage oil pump and reservoir tank. The scavenge stage of the pump continually evacuates the engine's lubricant, sending it to the remote reservoir tank. The tank allows high capacity without the penalty of windage losses, aeration, and control difficulty associated with oil collection in a conventional sump. The oil accumulates at the reservoir tank and is drawn back to the pressure stage of the system, providing uninterrupted and reliable pressurized oil under the most demanding driving conditions.

The pistons feature a friction-reducing skirt coating and hard anodized ring lands, reducing wear and adding to reliability. The ring package is lightweight and reactive for effective cylinder sealing well into the upper-rpm range.

Compression ratio has been moved up to 11:1, serious territory for a pump-gas powerplant, made possible through advanced engine management and the fast-burn technology built into the cylinder-head design. The pistons are full floating and are designed with the pin supports moved in. This allows for a shorter pin, which is stiffer and reduces reciprocating weight. The piston ring lands are anodized for improved surface hardness and wear resistance, while the skirt portion is coated with a lubricious polymer to reduce bore friction.

You might notice the recurring themes of strength and weight reduction, and this isn't coincidental. Lighter-weight components induce less internal engine stress, which is exponentially increased with rpm.Larger displacement through longer strokes increases piston speed, and these factors conspire to place a demanding load on a voluminous high-rpm engine. Reducing weight reduces component stresses. Figuring out how that can be accomplished while adding strength is a credit to the engineers on the program, and the goal of any racing engine builder.

Build It Better

The LS7 is not a product of a standard mass-production assembly line, but rather is created at the new GM Performance BuildCenter, where each engine is hand-assembled by an engine-building technician specialist. The facility is dedicated to crafting engines for specialty applications such as the Z06 in an environment akin to custom race-engine assembly. Each engine is viewed as an individual unit, and each is seen through the assembly process as the responsibility of a dedicated builder.

The engines are rigorously inspected and hot-tested in a 20-minute run cycle upon completion. Timothy Schag, site manager of the Performance Build Center, explains, "This process brings a higher level of quality because each builder is personally involved in every aspect of the assembly. It was important to step away from the high-volume world we all had lived in for so long and soak in the cadence of these specialized environments. We learned a lot and established a low-volume manufacturing system on par with the world's best niche builders, but we didn't lose sight of the quality already in place at GM."

We haven't failed to recognize the GM team's achievement in making this new small-block a milestone in the performance world.While we appreciate the engineering execution, it leaves us eager for the thrill of shaking down the new Z06 in the flesh. Indications are of0-60 performance in the 3s, and quarter-mile acceleration in the 11s. Missile-like acceleration on that level would be recommendation enough to indulge our own automotive requirements. However, acceleration and speed alone are only one dimension of the capabilities of this best-yetCorvette platform. We're anxiously awaiting a set of keys to experience it firsthand.

Camshaft Specs

Rocker-ratio intake: 1.80:1

Rocker-ratio exhaust: 1.80:1

Degrees Duration:

At camshaft: Intake: 0.331 in. Exhaust: 0.328 in.

At valve: Intake: 0.593 in. Exhaust: 0.588 in.

LS7 General Specs

Engine type: Cam-in-block 90-degree V-8Block configuration: Cast-aluminum with pressed-in cylinder sleeves and 6-bolt, forged-steel main bearing caps

Bore x Stroke (mm/in): 104.8x01.6/4.125x4.00

Displacement: 7.0L/427ci

Crankshaft: Forged steel

Connecting Rods: Forged titanium

Pistons: Cast aluminum

Compression Ratio: 11.0:1

Cylinder Heads: CNC-ported aluminum; 70cc chamber volume

Valve size, intake (mm/in): 56/2.20 (titanium)

Valve size, exhaust (mm/in): 41/1.61 (sodium-filled)

Camshaft: Hydraulic roller; 15 mm (.591 in) lift (intake and exhaust)

Rocker arms: 1.8:1; offset (intake only)

Air intake: Composite manifold with 90mm single-bore throttle body

Fuel: Premium required; 91-octane minimum

Horsepower: 500 (373 kW) @ 6,200 rpm

Torque (lb-ft): 475 (644 Nm) @ 4,800 rpm

Engine redline (rpm): 7,000